3 Hours **[Max Marks: 80]**

NB: 1. **Q.1** is **compulsory**
2. Answer **any three** out of remaining **five** questions
3. Assume any suitable data wherever required but justify the same

1 Answer the following:

(a)Draw a closed loop control schematic diagram (current control) for a buck converter and explain its operation. **05**

(b)Compare a multilevel inverter with a two level inverter and discuss its utility in actual practice. **05**

(c)Illustrate the use of heat-sink for thermal management in a power converter with the help of thermal equivalent circuit through a suitable example. **05**

(d)State and explain a typical MPPT application of dc-dc converter in Solar PV systems with the help of schematic **05**

2 (a) Explain the continuous current mode (CCM) and discontinuous current mode (DCM) of operation of a Boost Converter with the help of waveforms. Also illustrate the boundary condition between CCM and DCM. **10**

(b) Design an inductor for a buck converter working in CCM for the following specifications: V_o = 15V, I_o = 3A, f_s = 30 kHz and V_{in} = 25V. State all the assumptions made for the design. Refer the data sheet provided. **10**

3 (a) Design a boost converter for given data: input voltage V_{in}= 12-15V, output voltage V_o = 24V, output current I_o= 5A, f_s = 20kHz and consider output voltage ripple as 2%. Design the inductor for CCM operation. Also calculate and specify the capacitor, switch and diode ratings for the above design. Also state all assumptions made for the design. Refer the data sheet provided. **14**

(b) Draw a flyback converter and explain the operation with the help of waveforms. **06**

4 (a) Describe the use of dc-dc converter as power factor corrector **08**

(b) Discuss the following in the context of power switching converter design: **12**

(i) Selection voltage and current ratings of a power switch for a given application

(ii) De-rating of power switches with switching frequency and temperature.

(ii) Electrical isolation

5 (a) Explain the use and importance of the following in power switching converters. **12**

(i) Snubber circuit

(ii) EMI filter

(iii) Driver circuit

(b) Explain the operation of SEPIC and CUK converters with the help of diagrams in brief and derive the expression for voltage transfer ratio for both. **08**

6 (a) Design a transformer for a forward converter with all given data: input voltage V_{in}= 12-24V, output voltage V_o = 15V, output current I_o= 3A, f_s = 30kHz and consider output voltage ripple as 2%. Also state all assumption made for the design. Refer the data sheet provided. **10**

(b) Illustrate the space vector modulation (SVM) technique with switching sequence and duration of active vectors with the help of suitable diagrams. Explain method of switching vector generation in SVM. Compare SVM with sinusoidal PWM. **10**

Data for design problems

Physical, Electrical and Magnetic characteristics of ferrite cores

CORES without air gap	mean length per turn l_t mm	mean magnetic length l_m mm	core cross section area $A_e \times 100$ mm^2	window area $A_w \times 100$ mm^2	area product $A_p \times 10^4$ mm^4	effective relative permeability $\mu_e \pm 25\%$	A_L nH/turns^2 $\pm 25\%$
POTCORES - CEL HP$_3$C grade, (*Philip 3B7 grade)							
P 18/11	35.6	26	0.43	0.266	0.114	1480	3122
P 26/16	52	37.5	0.94	0.53	0.498	1670	5247
P 30/19	60	45.2	1.36	0.747	1.016	1760	6703
P 36/22	73	53.2	2.01	1.01	2.010	2030*	9500*
P 42/29	86	68.6	2.64	1.81	4.778	2120*	10250*
P 66/56	130	123	7.15	5.18	37.03		
EE - CORES - CEL HP$_3$C grade							
E 20/10/5	38	42.8	0.31	0.478	0.149	1770	1624
E 25/9/6	51.2	48.8	0.40	0.78	0.312	1840	1895
E 25/13/7	52	57.5	0.55	0.87	0.478	1900	2285
E 30/15/7	56	66.9	0.597	1.19	0.71		
E 36/18/11	70.6	78.0	1.31	1.41	1.847	2000	4200
E 42/21/9	77.6	108.5	1.07	2.56	2.739	2100	2613
E 42/21/15	93	97.2	1.82	2.56	4.659	2030	4778
E 42/21/20	99	98.0	2.35	2.56	6.016	2058	6231
E 65/32/13	150	146.3	2.66	5.37	14.284	2115	4833
UU - CORES							
UU 15	44	48	0.32	0.59	1.190		1100
UU 21	55	68	0.55	1.01	0.555		1425
UU 23	64	74	0.61	1.36	0.823		1425
UU 60	183	184	1.96	11.65	22.83		1900
UU 100	29.3	308	6.45	29.14	187.95		3325
TOROIDS - CEL HP$_3$C							
T 10	12.8	23.55	0.062	0.196	0.012	2300	765
T 12	19.2	30.40	0.12	0.442	0.053	2300	1180
T 16	24.2	38.70	0.20	0.785	0.157	2300	1482
T 20	25.2	47.30	0.22	0.950	0.213	2300	1130
T 27	34.1	65.94	0.42	1.651	0.698	2300	1851
T 32	39.6	73.00	0.61	1.651	1.010	2300	2427
T 45	54.7	114.50	0.93	6.157	5.756	2300	2367

Wire Size Table

SWG	Dia with enamel mm	Area of bare conductor mm^2	R/Km @20°C ohms	Weight Kg/km
45*	0.086	0.003973	4340	0.0369
44	0.097	0.005189	3323	0.0481
43	0.109	0.006567	2626	0.0610
42	0.119	0.008107	2127	0.0750
41	0.132	0.009810	1758	0.0908
40*	0.142	0.011675	1477	0.1079
39	0.152	0.013700	1258	0.1262
38*	0.175	0.018240	945.2	0.1679
37	0.198	0.023430	735.9	0.2202
36	0.218	0.029270	589.1	0.2686
35*	0.241	0.035750	482.2	0.3281
34	0.264	0.04289	402.0	0.3932
33	0.287	0.05067	340.3	0.4650
32*	0.307	0.05910	291.7	0.5408
31	0.330	0.06818	252.9	0.6245
30	0.351	0.07791	221.3	0.7121
29*	0.384	0.09372	184.0	0.8559
28	0.417	0.11100	155.3	1.0140
27	0.462	0.13630	126.5	1.2450
26*	0.505	0.16420	105.0	1.4990
25	0.561	0.20270	85.1	1.8510
24*	0.612	0.24520	70.3	2.2330
23	0.665	0.29190	59.1	2.6550
22*	0.770	0.39730	43.4	3.6070
21	0.874	0.51890	33.2	4.7020
20*	0.978	0.65670	26.3	5.9390
19	1.082	0.81070	21.3	7.3240
18*	1.293	1.16700	14.8	10.5370
17	1.501	1.58900	10.8	14.3130
16	1.709	2.07500	8.3	18.6780
15	1.920	2.62700	6.6	23.6400
14*	2.129	3.24300	5.3	29.1500
13	2.441	4.28900	4.0	38.5600
12	2.756	5.48000	3.1	49.2200
11	3.068	6.81800	2.5	61.0000
10	3.383	8.30200	2.1	74.0000
9	3.800	10.5100	1.6	94.0000
8	4.219	12.9700	1.3	116.0000